

Non-isolated DC/DC Converter Modules-HR Series

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1. Introduction

Power supplies used on the electronic equipment market are being required to be small, highly efficiency and inexpensive. In order to respond to these market needs, Shindengen has released the HR series of non-isolated DC/DC converter

modules aimed at small and medium-capacity power supply systems. This article provides an introduction to the newest member of this series, the HRD12003 (output voltage: 12 V, output current: 3 A).

2. Overview

Members of the HR series consist of non-isolated DC/DC converter modules employing a chopper circuit.

A MOSFET device is used for the main switching device and the conversion frequency has been set at 300 kHz for reduced size and high efficiency. Members of the HR series also feature a built-in choke, enabling the configuration of a DC/DC converter simply by externally attaching a capacitor. Heat radiation fins are not required. The HRD12003 has the same appearance as the HRD05003 and is also pin-compatible. The HR series is available in a total of six types, consisting of four voltage step-down types and two polarity inversion types (Photo 1).

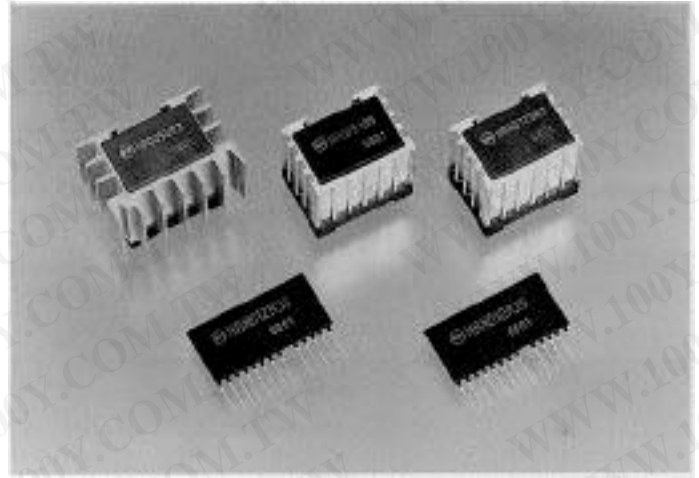


Photo 1 HR series

3. Features

- 1) Wide input voltage range
Voltage step-down types: DC 8~40 V ($V_o = 5V$), DC 17~40 V ($V_o = 12V$), polarity inversion types: DC 8~32V
- 2) Wide output voltage variable range by an externally connected resistor
Voltage step-down types: DC 3.3~24V ($V_o = 5V$), DC 10.8~24V ($V_o = 12V$), polarity inversion types: DC -5 to -15V
- 3) Fixed switching frequency system: 300 kHz
- 4) Compact size and low price by equipping with Shindengen bare chips
- 5) Overcurrent protection function (constant current droop available for voltage step-down types only)
- 6) Remote ON/OFF function

4. Specifications and Characteristics

Specifications and characteristics according to the standard connection circuit diagrams (Fig. 1) are as shown in Table 1.

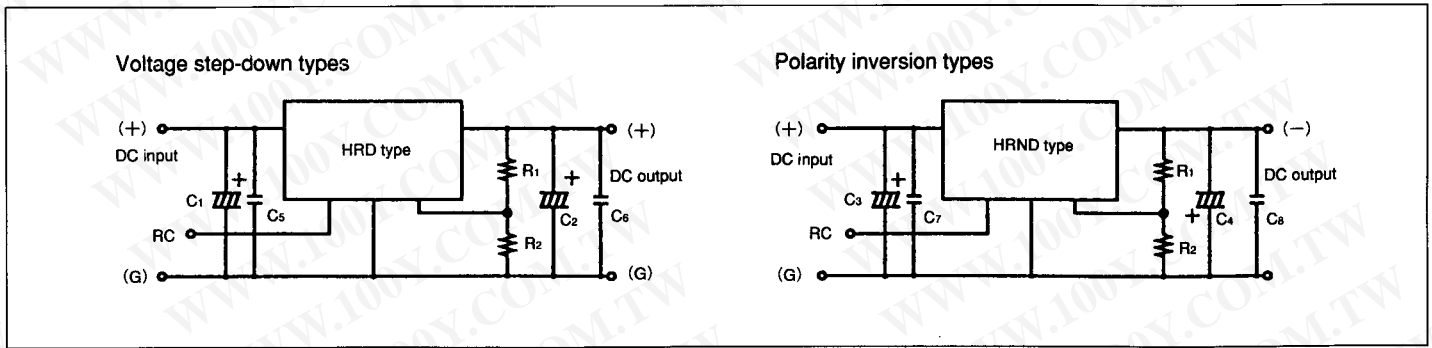


Fig. 1 Standard connection circuit diagrams

Reference externally connected components

Name	C1	C2
HRD050R6	50V 39 μ F	50V 180 μ F 85m Ω
HRD051R5	50V 150 μ F	50V 220 μ F 75m Ω
HRD05003	50V 390 μ F	50V 220 μ F \times 2 75m Ω /2
HRD12003	50V 390 μ F	50V 390 μ F \times 2 45m Ω /2

Reference externally connected components

Name	C3	C4
HRND12R35	35V 100 μ F	35V 330 μ F \times 2 60m Ω /2
HRND120R7	35V 270 μ F	35V 390 μ F \times 2 50m Ω /2

Notes: *1: Use a high frequency of 100 kHz for output capacitors C2 and C4.

*2: Connect the RC terminal to the ground line when not using remote control.

*3: R1 and R2 are output voltage variable resistors (used in the open state when not varying output voltage)

*4: Use ceramic or film capacitors having capacitance of 0.01~1 μ F for C5, C6 and C7.

Item	Name	Voltage step-down types				Polarity inversion types	
		HRD050R6	HRD051R5	HRD05003	HRD12003	HRND12R35	HRND120R7
Input voltage	[V]	8~40				17~40	
Output voltage	[V]	5				12	
Output current	[A]	0~0.6	0~1.5	0~3	0~3	0~0.35	0~0.7
Output accuracy	[%]	\pm 5				\pm 5	
Ripple voltage (typ.)	[mV]	25				25	
Output voltage variable range	[V]	3.3~24*			10.8~24*	-5~-15*	
Efficiency (typ.)	[%]	75	78	80	90	80	80
Provided (automatic reset)		Provided (automatic reset)					
Remote ON/OFF		Provided					
Operating ambient temperature	[$^{\circ}$ C]	-10~80 (50~80 deleting)					
Storage temperature	[$^{\circ}$ C]	-30~85					

Table 1 Specifications

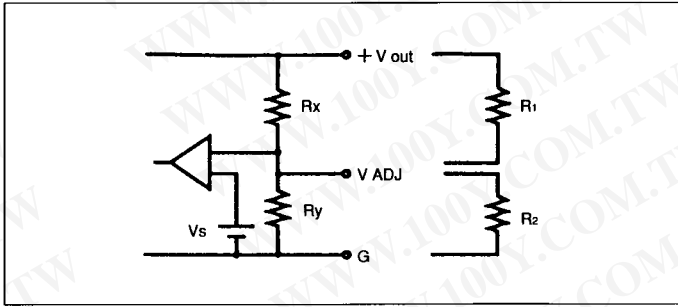
Notes: *1: Characteristics are shown when using reference externally connected components in the standard connection circuit diagram.

*2: Conditions for ripple voltage and efficiency consist of input voltage of 24 V and the rated output current.

*: According to externally connected resistor.

5. Output Voltage Variation Method

The output voltage of the HR series is set at 5 V for voltage step-down types (12 V for the HRD12003 only), and -12 V for polarity inversion types. When other voltages are required, an external output voltage variable resistor is added to obtain the required voltage. Voltage setting resistance values are determined according to Tables 2 and 4 as well as the following equations.



◆ Voltage Step-down Type

① Output voltage down:

$$R_1 = \frac{R_x \times R_y (V_o - V_s)}{R_x \times V_s - R_y (V_o - V_s)} \quad (R_2 \text{ is not connected})$$

② Output voltage up:

$$R_2 = \frac{R_x \times R_y \times V_s}{R_y (V_o - V_s) - R_x \times V_s} \quad (R_1 \text{ is not connected})$$

Name	HRD050R6, HRD051R5, HRD05003	HRD12003
Vs	2.5V	2.5V
Rx	6.2kΩ	6.2kΩ
Ry	6.2kΩ	1.63kΩ
Vo	Desired output voltage [V]	

Table 2 Voltage setting resistance calculation table

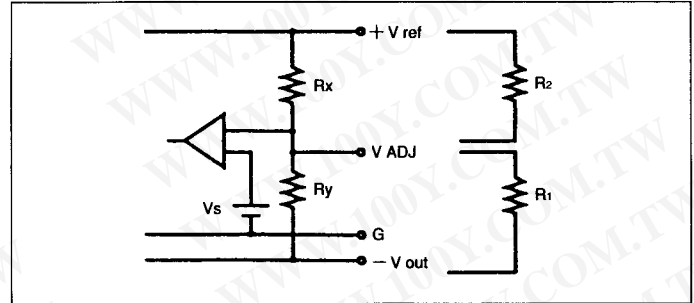
*1: Since derating will change when the output voltage is changed, use a resistance value so that the operating case surface temperature does not exceed 100°C.

*2: This circuit type (voltage step-down type) requires a difference between the input voltage and output voltage. Since the minimum required voltage difference in the case of varying the output voltage varies according to input and output conditions, determine the minimum input voltage from the following equation and Table 3.

$$V_{in} = \frac{V_o + K}{D}$$

Vin	Minimum direct current input voltage [V]
Vo	Desired output voltage [V]
D	0.85 (maximum duty)
K	0.8 (coefficient)

Table 3 Minimum input voltage calculation table



◆ Voltage Step-up Type

① Output voltage (absolute value) down:

$$R_1 = \frac{R_y (V_o + V_s)}{12 - V_o} \quad (R_2 \text{ is not connected})$$

② Output voltage (absolute value) up:

$$R_2 = \frac{R_y (V_{ref} - V_s)}{V_o - 12} \quad (R_1 \text{ is not connected})$$

Name	HRND12R35, HRND120R7
Vref	2.5V
Vs	1V
Vx	3kΩ
Ry	26kΩ
Vo	Desired output voltage [V] (absolute value)

Table 4 Voltage setting resistance calculation table

*1: Since derating will change when the output voltage is changed, use a resistance value so that the operating case surface temperature does not exceed 100°C.

*2: Over an input voltage range of 28 ~ 32 V in the case of varying the output voltage to -5 V, the output rated current will be decreased from 0.35 A to 0.2 A in the HRND12R35, and from 0.7 A to 0.4 A in the HRND120R7. In addition, over an input voltage range of 8 ~ 10 V in the case of varying the output voltage to -15 V, the output rated current will be decreased from 0.35 A to 0.2 A in the HRND12R35, and from 0.7 A to 0.4 A in the HRND120R7.

6. Overvoltage Protection

Members of the HR series are not provided with an overvoltage protection function. In the event voltage should happen to increase excessively due to a fault or other problem within the module, there is a fault mode particularly in the

voltage step-down types in which the input voltage appears directly at the output even if operation is interrupted, which may result in damage to the load. Always make sure to add an overvoltage protective circuit (Fig. 2) to prevent this.

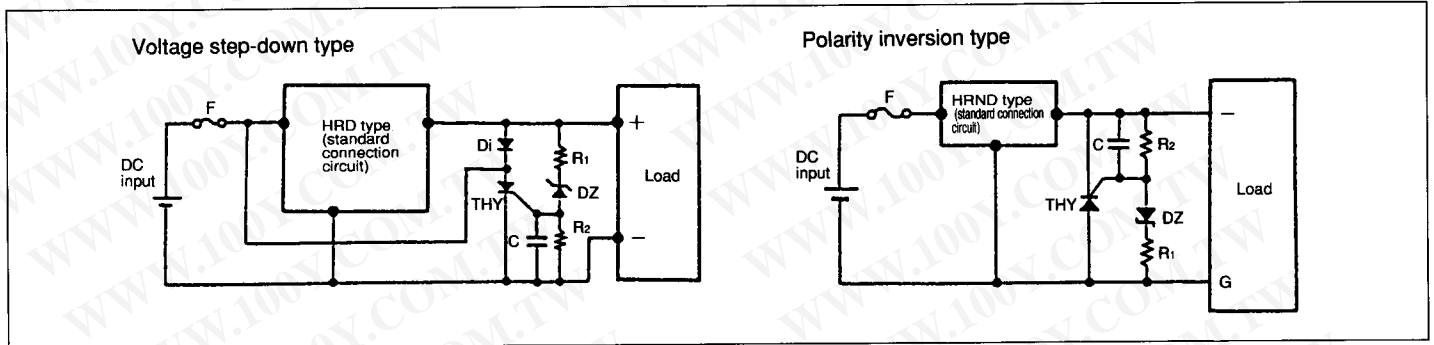


Fig. 2 Overvoltage protective circuit diagram

Applicable voltage	Voltage step-down type			Polarity inversion type		
	5V			12V	-12V	
Applicable product	HRD050R6	HRD051R5	HRD05003	HRD12003	HRND12R35	HRND120R7
C (Filter capacitor)	MMH334K63 (63V 0.33 μF)				MMH334K63 (63V 0.33 μF)	
Di (Diode)	D1N120U (200V 1A)	D2L20U (200V 1.5A)	S3L20U (200V 3A)			
Dz (Zener diode)	RD5.6EB1 (5.29~5.5V)			RD15E (13.8~15.6V)		
R1 (Resistor)				1/5W 22Ω		
R2 (Resistor)				1/5W 1kΩ		
THY (Thyristor)	2P4M (400V 2A)		5P4SM (400V 5A)		2P4M (400V 2A)	
F (Fuse)	1A	2A	5A		1A	2A

Table 5 Table of overvoltage protective circuit constants

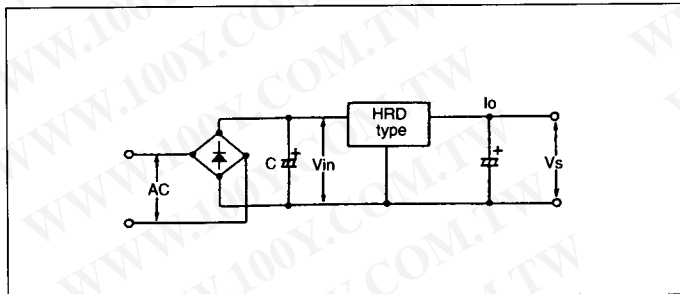
Notes: *1: Output current ratings are used for the conditions.

*2: Use a power supply having a capacity larger than the fuse capacity for the power supply used on the input side.

7. Determination of Input Capacitor in the case of Full-Wave Rectification of AC Input Voltage

In the case of using commercial AC current following full-wave rectification, the input ripple voltage differs considerably according to the value of the input capacitor. It is recommended that the input voltage ripple be no more than 20% of the input voltage. The input capacitor is determined from the following equation and Table 6.

In addition, in the case of full-wave rectification, care must



be taken so that the input voltage does not exceed the maximum value of the rated input voltage. (A voltage of AC 24 V is assumed for the AC input voltage of members of the HR series, and this is applicable to voltage step-down types only.)

$$C = \frac{T \times V_o \times I_o \times 100}{\Delta V \times V_{in} \times \eta}$$

C	Capacitor capacitance [F]
T	Frequency cycle time of input ripple [s] (10 ms in the case of commercial AC full-wave rectification)
V _o	Output voltage [V]
I _o	Output current [A]
ΔV	Input ripple voltage [V] (20% or less of V _{in})
V _{in}	Minimum DC input voltage following full-wave rectification of AC input voltage [V]
η	Efficiency of HR series [%]

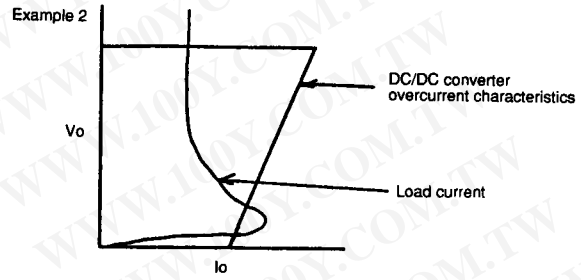
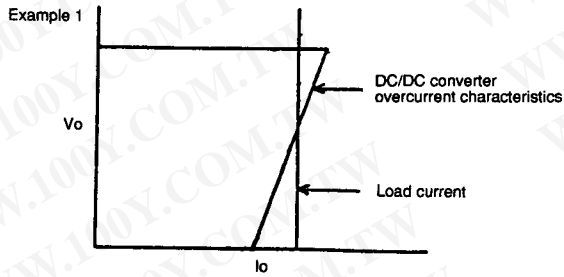
Table 6 Input capacitor calculation table

8. Precautions Concerning Load Current

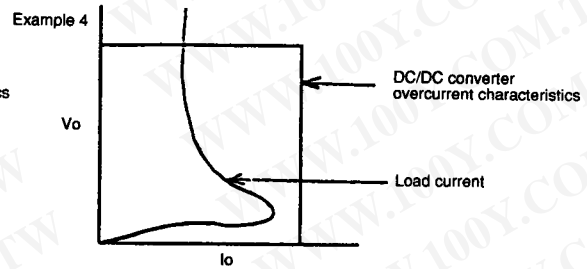
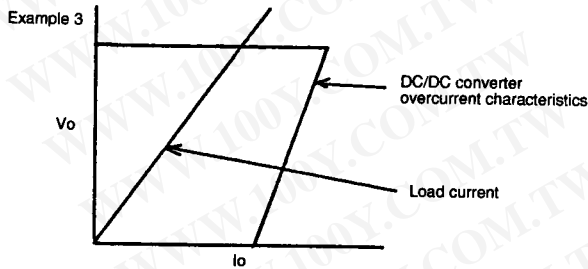
The output of DC/DC converters will not rise when there are two or more points at which the overcurrent characteristics of

the DC/DC converter and the load current cross when applying the input voltage.

Does not rise (DC/DC converter overcurrent characteristics)



Rises (DC/DC converter overcurrent characteristics)



Countermeasures:

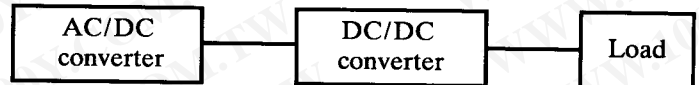
1. Reduce the number of points at which DC/DC converter overcurrent characteristics and load current cross to only 1 point.
2. Select a product having large overcurrent characteristics for the DC/DC converter.
3. Apply the load current after the DC/DC converter has risen.

9. Precautions Concerning System Power Supplies

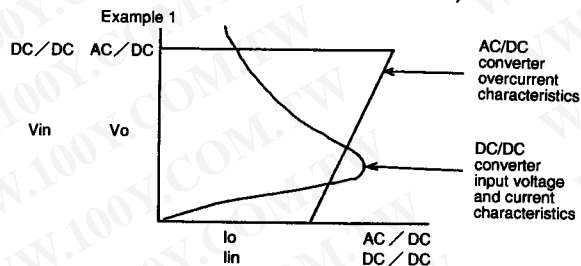
The following possibilities can be considered when the output of DC/DC converter does not rise when combining an AC/DC converter and DC/DC converter.

The DC/DC converter output will not rise when there are two more points at which the overcurrent characteristics of the

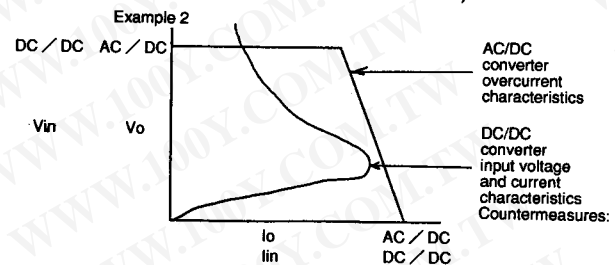
AC/DC converter and the input current of the DC/DC converter cross when the input voltage is applied.



When output DC/DC converter does not rise (overcurrent characteristics of AC/DC converter)



When output DC/DC converter rises (overcurrent characteristics of AC/DC converter)



- *1: Reduce the number of points at which AC/DC converter overcurrent characteristics and DC/DC converter input current cross to only 1 point.
2. Select a product having large overcurrent characteristics for the AC/DC converter.
3. Apply the load current after the AC/DC converter has risen. For example, this can be done by using the remote control function of the DC/DC converter.

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